

PCT

NOTIFICATION OF ELECTION
 (PCT Rule 61.2)

To:

United States Patent and Trademark
 Office
 (Box PCT)
 Crystal Plaza 2
 Washington, DC 20231
 ÉTATS-UNIS D'AMÉRIQUE

Date of mailing (day/month/year) 23 June 1999 (23.06.99)	in its capacity as elected Office
International application No. PCT/NL98/00602	Applicant's or agent's file reference BO 41592
International filing date (day/month/year) 20 October 1998 (20.10.98)	Priority date (day/month/year) 20 October 1997 (20.10.97)
Applicant BOONE, Marinus, Marias et al	

1. The designated Office is hereby notified of its election made:

in the demand filed with the International Preliminary Examining Authority on:

18 May 1999 (18.05.99)

in a notice effecting later election filed with the International Bureau on:

2. The election was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	Authorized officer Jean-Marie McAdams Telephone No.: (41-22) 338.83.38
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NOTIFICATION OF THE RECORDING
OF A CHANGE(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)Date of mailing (day/month/year)
22 March 2000 (22.03.00)

From the INTERNATIONAL BUREAU

To:

DE BRUIJN, Leendert, C.
Nederlandsch Octrooibureau
Scheveningseweg 82
P.O. Box 29720
NL-2502 LS The Hague
PAYS-BASApplicant's or agent's file reference
BO 41592

IMPORTANT NOTIFICATION

International application No.
PCT/NL98/00602International filing date (day/month/year)
20 October 1998 (20.10.98)

1. The following indications appeared on record concerning:

 the applicant the inventor the agent the common representative

Name and Address

MERKS, Ivo, Léon, Diane, Marie
Dakarhof 56
NL-2622 CR Delft
Netherlands

State of Nationality

State of Residence

Telephone No.

Facsimile No.

Teleprinter No.

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

 the person the name the address the nationality the residence

Name and Address

MERKS, Ivo, Léon, Diane, Marie
Karel de Grotelaan 75
NL-5615 SP Eindhoven
Netherlands

State of Nationality

State of Residence

Telephone No.

Facsimile No.

Teleprinter No.

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

<input checked="" type="checkbox"/> the receiving Office	<input type="checkbox"/> the designated Offices concerned
<input type="checkbox"/> the International Searching Authority	<input checked="" type="checkbox"/> the elected Offices concerned
<input type="checkbox"/> the International Preliminary Examining Authority	<input type="checkbox"/> other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Authorized officer

S. Cruz

Facsimile No.: (41-22) 740.14.35

Telephone No.: (41-22) 338.83.38

Nederlandsch Octrooibureau

PATENT COOPERATION TREATY

INGEK. 10 MEI 1999

Paraaf Bewerken

PCT

NOTICE INFORMING THE APPLICANT OF THE
COMMUNICATION OF THE INTERNATIONAL
APPLICATION TO THE DESIGNATED OFFICES

(PCT Rule 47.1(c), first sentence)

Date of mailing (day/month/year)

29 April 1999 (29.04.99)

Applicant's or agent's file reference

BO 41592

IMPORTANT NOTICE

International application No.

PCT/NL98/00602

International filing date (day/month/year)

20 October 1998 (20.10.98)

Priority date (day/month/year)

20 October 1997 (20.10.97)

Applicant

TECHNISCHE UNIVERSITEIT DELFT et al

1. Notice is hereby given that the International Bureau has communicated, as provided in Article 20, the international application to the following designated Offices on the date indicated above as the date of mailing of this Notice:

AU,CN,EP,IL,JP,KP,KR,US

In accordance with Rule 47.1(c), third sentence, those Offices will accept the present Notice as conclusive evidence that the communication of the international application has duly taken place on the date of mailing indicated above and no copy of the international application is required to be furnished by the applicant to the designated Office(s).

2. The following designated Offices have waived the requirement for such a communication at this time:

AL,AM,AP,AT,AZ,BA,BB,BG,BR,BY,CA,CH,CU,CZ,DE,DK,EA,EE,ES,FI,GB,GD,GE,GH,GM,HR,HU,
ID,IS,KE,KG,KZ,LC,LK,LR,LS,LT,LU,LV,MD,MG,MK,MN,MW,MX,NO,NZ,OA,PL,PT,RO,RU,SD,SE,
SG,SI,SK,SL,TJ,TM,TR,TT,UA,UG,UZ,VN,YU,ZW

The communication will be made to those Offices only upon their request. Furthermore, those Offices do not require the applicant to furnish a copy of the international application (Rule 49.1(a-bis)).

3. Enclosed with this Notice is a copy of the international application as published by the International Bureau on
29 April 1999 (29.04.99) under No. WO 99/21400

REMINDER REGARDING CHAPTER II (Article 31(2)(a) and Rule 54.2)

If the applicant wishes to postpone entry into the national phase until 30 months (or later in some Offices) from the priority date, a demand for international preliminary examination must be filed with the competent International Preliminary Examining Authority before the expiration of 18 months from the priority date.

It is the applicant's sole responsibility to monitor the 18-month time limit.

Note that only an applicant who is a national or resident of a PCT Contracting State which is bound by Chapter II has the right to file a demand for international preliminary examination.

REMINDER REGARDING ENTRY INTO THE NATIONAL PHASE (Article 22 or 39(1))

If the applicant wishes to proceed with the international application in the national phase, he must, within 20 months or 30 months, or later in some Offices, perform the acts referred to therein before each designated or elected Office.

For further important information on the time limits and acts to be performed for entering the national phase, see the Annex to Form PCT/IB/301 (Notification of Receipt of Record Copy) and Volume II of the PCT Applicant's Guide.

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. (41-22) 740.14.35

Authorized officer

J. Zahra

Telephone No. (41-22) 338.83.38

PCT

19. 11. 98

REQUEST

The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty.

For receiving Office use only

PCT/NL 98 / 00602

International Application No.

20 OCT 1998
International Filing Date

20. 10. 98

BUREAU VOOR DE INDUSTRIËLE EIGENDOM
P.C.T. INTERNATIONAL APPLICATION

Name of receiving Office and "PCT International Application"

Applicant's or agent's file reference
(if desired) (12 characters maximum)

BO 41592

Box No. I TITLE OF INVENTION Hearing aid for improving the hearing ability of the hard of hearing

Box No. II APPLICANT

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

TECHNISCHE UNIVERSITEIT DELFT
P.O. Box 5046
NL-2600 GA DELFT
the Netherlands

This person is also inventor.

Telephone No.

Facsimile No.

Teleprinter No.

State (that is, country) of nationality:
the Netherlands (NL)

State (that is, country) of residence:
the Netherlands (NL)

This person is applicant all designated States all designated States except the United States of America the United States of America only the States indicated in the Supplemental Box

Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

STICHTING VOOR DE TECHNISCHE WETENSCHAPPEN
P.O. Box 3021
NL-3502 GA Utrecht
the Netherlands

This person is:

applicant only

applicant and inventor

inventor only (If this check-box is marked, do not fill in below)

State (that is, country) of nationality:
the Netherlands (NL)

State (that is, country) of residence:
the Netherlands (NL)

This person is applicant all designated States all designated States except the United States of America the United States of America only the States indicated in the Supplemental Box

Further applicants and/or (further) inventors are indicated on a continuation sheet.

Box No. IV AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:

agent

common representative

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)

DE BRUIJN, Leendert C. *[et al]*
Nederlandsch Octrooibureau
Scheveningseweg 82, P.O. Box 29720
NL-2502 LS The Hague
THE NETHERLANDS

Telephone No.

70 3527500

Facsimile No.

70 3527528

Teleprinter No.

Address for correspondence: Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Continuation of Box No. III FURTHER APPLICANT(S) AND/OR (FURTHER) INVENTOR(S)

If none of the following sub-boxes is used, this sheet should not be included in the request.

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

BOONE, Marinus Marias
Voorweg 105A
NL-2715 NG ZOETERMEER
the Netherlands

This person is:

applicant only
 applicant and inventor
 inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:
the Netherlands (NL)State (that is, country) of residence:
the Netherlands (NL)

This person is applicant for the purposes of: all designated States all designated States except the United States of America the United States of America only the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

BERKHOUT, Augustinus Johannes
Nieuwe Parklaan 30
NL-2597 LD DEN HAAG
the Netherlands

This person is:

applicant only
 applicant and inventor
 inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:
the Netherlands (NL)State (that is, country) of residence:
the Netherlands (NL)

This person is applicant for the purposes of: all designated States all designated States except the United States of America the United States of America only the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

MERKS, Ivo Léon Diane Marie
Dakarhof 56
NL-2622 CR DELFT
the Netherlands

This person is:

applicant only
 applicant and inventor
 inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:
the Netherlands (NL)State (that is, country) of residence:
the Netherlands (NL)

This person is applicant for the purposes of: all designated States all designated States except the United States of America the United States of America only the States indicated in the Supplemental Box

Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country. The country of the address indicated in this Box is the applicant's State (that is, country) of residence if no State of residence is indicated below.)

This person is:

applicant only
 applicant and inventor
 inventor only (If this check-box is marked, do not fill in below.)

State (that is, country) of nationality:

State (that is, country) of residence:

This person is applicant for the purposes of: all designated States all designated States except the United States of America the United States of America only the States indicated in the Supplemental Box

Further applicants and/or (further) inventors are indicated on another continuation sheet.

Box No.V DESIGNATION OF STATES

The following designations are hereby made under Rule 4.9(a) (mark the applicable check-boxes; at least one must be marked):

Regional Patent

AP ARIPO Patent: GH Ghana, GM Gambia, KE Kenya, LS Lesotho, MW Malawi, SD Sudan, SZ Swaziland, UG Uganda, ZW Zimbabwe, and any other State which is a Contracting State of the Harare Protocol and of the PCT

EA Eurasian Patent: AM Armenia, AZ Azerbaijan, BY Belarus, KG Kyrgyzstan, KZ Kazakhstan, MD Republic of Moldova, RU Russian Federation, TJ Tajikistan, TM Turkmenistan, and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT

EP European Patent: AT Austria, BE Belgium, CH and LI Switzerland and Liechtenstein, CY Cyprus, DE Germany, DK Denmark, ES Spain, FI Finland, FR France, GB United Kingdom, GR Greece, IE Ireland, IT Italy, LU Luxembourg, MC Monaco, NL Netherlands, PT Portugal, SE Sweden, and any other State which is a Contracting State of the European Patent Convention and of the PCT

OA OAPI Patent: BF Burkina Faso, BJ Benin, CF Central African Republic, CG Congo, CI Côte d'Ivoire, CM Cameroon, GA Gabon, GN Guinea, ML Mali, MR Mauritania, NE Niger, SN Senegal, TD Chad, TG Togo, and any other State which is a member State of OAPI and a Contracting State of the PCT (if other kind of protection or treatment desired, specify on dotted line)

National Patent (if other kind of protection or treatment desired, specify on dotted line):

AL Albania

AM Armenia

AT Austria

AU Australia

AZ Azerbaijan

BA Bosnia and Herzegovina

BB Barbados

BG Bulgaria

BR Brazil

BY Belarus

CA Canada

CH and LI Switzerland and Liechtenstein

CN China

CU Cuba

CZ Czech Republic

DE Germany

DK Denmark

EE Estonia

ES Spain

FI Finland

GB United Kingdom

GE Georgia

GH Ghana

GM Gambia

GW Guinea-Bissau

HR Croatia

HU Hungary

ID Indonesia

IL Israel

IS Iceland

JP Japan

KE Kenya

KG Kyrgyzstan

KP Democratic People's Republic of Korea

KR Republic of Korea

KZ Kazakhstan

LC Saint Lucia

LK Sri Lanka

LR Liberia

LS Lesotho

LT Lithuania

LU Luxembourg

LV Latvia

MD Republic of Moldova

MG Madagascar

MK The former Yugoslav Republic of Macedonia

MN Mongolia

MW Malawi

MX Mexico

NO Norway

NZ New Zealand

PL Poland

PT Portugal

RO Romania

RU Russian Federation

SD Sudan

SE Sweden

SG Singapore

SI Slovenia

SK Slovakia

SL Sierra Leone

TJ Tajikistan

TM Turkmenistan

TR Turkey

TT Trinidad and Tobago

UA Ukraine

UG Uganda

US United States of America

UZ Uzbekistan

VN Viet Nam

YU Yugoslavia

ZW Zimbabwe

Check-boxes reserved for designating States (for the purposes of a national patent) which have become party to the PCT after issuance of this sheet:

GD. GRENADA

.....

Precautionary Designation Statement: In addition to the designations made above, the applicant also makes under Rule 4.9(b) all other designations which would be permitted under the PCT except any designation(s) indicated in the Supplemental Box as being excluded from the scope of this statement. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. (Confirmation of a designation consists of the filing of a notice specifying that designation and the payment of the designation and confirmation fees. Confirmation must reach the receiving Office within the 15-month time limit.)

Box No. VI PRIORITY CLAIM		<input type="checkbox"/> Further priority claims are indicated in the Supplemental Box.		
Filing date of earlier application (day/month/year)	Number of earlier application	Where earlier application is:		
		national application: country	regional application: regional Office	international application: receiving Office
item (1) (20. 10. 97) 20 October 1997	1007321	the Netherlands		
item (2)				
item (3)				

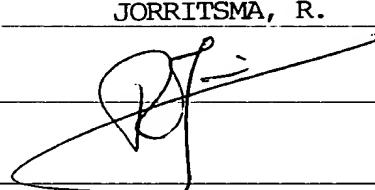
The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) (only if the earlier application was filed with the Office which for the purposes of the present international application is the receiving Office) identified above as item(s): 1

* Where the earlier application is an ARIPO application, it is mandatory to indicate in the Supplemental Box at least one country party to the Paris Convention for the Protection of Industrial Property for which that earlier application was filed (Rule 4.10(b)(ii)). See Supplemental Box.

Box No. VII INTERNATIONAL SEARCHING AUTHORITY			
Choice of International Searching Authority (ISA) (if two or more International Searching Authorities are competent to carry out the international search, indicate the Authority chosen; the two-letter code may be used):	Request to use results of earlier search; reference to that search (if an earlier search has been carried out by or requested from the International Searching Authority):		
ISA / EPA	Date (day/month/year)	Number	Country (or regional Office)
	23 June 1998	SN 30078 NL	the Netherlands

Box No. VIII CHECK LIST; LANGUAGE OF FILING	
This international application contains the following number of sheets:	This international application is accompanied by the item(s) marked below:
request : 4	<input checked="" type="checkbox"/> fee calculation sheet
description (excluding sequence listing part) : 8	<input type="checkbox"/> separate signed power of attorney
claims : 2	<input type="checkbox"/> copy of general power of attorney; reference number, if any:
abstract : 1	<input type="checkbox"/> statement explaining lack of signature
drawings : 3	<input type="checkbox"/> priority document(s) identified in Box No. VI as item(s):
sequence listing part of description :	<input type="checkbox"/> translation of international application into (language):
Total number of sheets : 18	<input type="checkbox"/> separate indications concerning deposited microorganism or other biological material
	<input type="checkbox"/> nucleotide and/or amino acid sequence listing in computer readable form
	<input checked="" type="checkbox"/> other (specify): copy search report

Figure of the drawings which should accompany the abstract: 1	Language of filing of the international application: Dutch
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Box No. IX SIGNATURE OF APPLICANT OR AGENT	
Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the request).	
JORRITSMA, R.	
	

Nederlandsch Octrooibureau, The Hague 20 October 1998

For receiving Office use only		
1. Date of actual receipt of the purported international application:	20 OCT 1998	(20. 10. 98)
3. Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application:		
4. Date of timely receipt of the required corrections under PCT Article 11(2):		
5. International Searching Authority (if two or more are competent): ISA /	6. <input type="checkbox"/> Transmittal of search copy delayed until search fee is paid.	2. Drawings:
		<input checked="" type="checkbox"/> received:
		<input type="checkbox"/> not received:

For International Bureau use only		
Date of receipt of the record copy by the International Bureau:	18 NOVEMBER 1998	(18. 11. 98)

Gehoorinrichting voor het verbeteren van de verstaanbaarheid voor slechthorenden.

De uitvinding heeft betrekking op een gehoorinrichting voor het 5 verbeteren van de verstaanbaarheid voor slechthorenden, omvattende een array van microfoons, waarvan de elektrische uitgangssignalen worden toegevoerd aan tenminste één bij een oor behorend overdrachtstraject.

Een dergelijke inrichting is bekend uit het artikel "Development of a directional hearing instrument based on array technology" 10 verschenen in "Journal of the Acoustical Society of America", Vol. 94, uitgave 2, Pt. 1, pagina's 785-798 van augustus 1993.

Het is algemeen bekend, dat het gehoorverlies bij personen kan worden gecompenseerd door middel van een gehoorinrichting, waarin 15 versterking van het ontvangen geluid wordt toegepast. In omgevingen met achtergrond ruis, bijvoorbeeld wanneer meerdere personen spreken, zoals bij een cocktailparty, versterkt de gehoorinrichting zowel de gewenste spraak als ruis, waardoor de verstaanbaarheid niet wordt verbeterd.

In het hierboven genoemde artikel is door de auteurs een verbeteringsvoorstel beschreven. De uit het artikel bestaande gehoorinrichting bestaat uit een array van bijvoorbeeld 5 directionele microfoons, waardoor het mogelijk is dat de slechthorende een spreker kan verstaan die zich recht tegenover hem bevindt. De achtergrond ruis die afkomstig is uit andere richtingen wordt door de array onderdrukt.

De uitvinding heeft ten doel te voorzien in een gehoorinrichting van de in de aanhef genoemde soort, waarbij de hierboven genoemde nadelen worden vermeden en de verstaanbaarheid en de natuurgetrouwheid van de weergave op een eenvoudige wijze wordt verbeterd.

Dit doel wordt volgens de uitvinding daardoor bereikt, dat 30 middelen aanwezig zijn om uit de uitgangssignalen van de microfoons twee array-uitgangssignalen af te leiden, waarbij de array twee onder een hoek ten opzichte van elkaar verlopende hoofdgevoeligheidsrichtingen heeft, die elk zijn toegevoegd aan een array-uitgangssignaal en dat elk array-uitgangssignaal wordt toegevoerd aan een eigen bij een 35 oor van een slechthorende behorend overdrachtstraject.

Hierbij worden de signalen uit de microfoons van de array gecombineerd tot een signaal voor het linker oor en een signaal voor het rechter oor. De array heeft twee onder een hoek ten opzichte van

elkaar verlopende hoofdgevoelighedsrichtingen of hoofdlobben, waarbij het linker-oorsignaal in hoofdzaak het uit de eerste hoofdgevoelighedsrichting afkomstige geluid vertegenwoordigt en het rechter-oorsignaal dat uit de andere hoofdgevoelighedsrichting voorstelt. De 5 array-uitgangssignalen, te weten het linker-oorsignaal en het rechter-oorsignaal worden via een eigen overdrachtstraject toegevoerd aan het linker respectievelijk rechter oor. In dit overdrachtstraject wordt versterking van het signaal en omzetting van het elektrische signaal in een geluidssignaal toegepast.

10 De verschillende hoofdlobben introduceren een niveauverschil tussen de aan de oren toe te voeren signalen. Gevonden is dat niet alleen geluidsbronnen beter kunnen worden gelokaliseerd, maar dat door de richtingswerking verder ook achtergrond ruis wordt onderdrukt, waardoor de verstaanbaarheid van de spraak ondanks de aanwezige ruis 15 wordt verbeterd.

De array kan op voordelige wijze aan de voorzijde van een bril-
montuur en/of op de brillenpoten of veren worden aangebracht.

Bij een bij voorkeur toe te passen uitvoeringsvorm is bovendien 20 elke brillenpoot voorzien van een array van microfoons, waarbij de uitgangssignalen van deze arrays elk aan het ene respectievelijk andere overdrachtstraject worden toegevoerd.

Hierdoor wordt niet alleen bereikt dat bij hoge frequenties in het hoorbare geluidsgebied maar ook bij lagere frequenties de verstaanbaarheid wordt verbeterd.

25 Verdere uitwerkingen van de uitvinding zijn in de volgconclusies omschreven.

De uitvinding zal hierna nader worden toegelicht aan de hand van de tekeningen. In de tekeningen tonen:

Figuur 1 een uitvoeringsvorm van de gehoorinrichting volgens de uit-
30 vinding;

Figuur 2 een meer gedetailleerde uitvoeringsvorm van de gehoorinrich-
ting volgens de uitvinding;

Figuur 3 een andere uitvoeringsvorm van de gehoorinrichting volgens de uitvinding;

35 Figuur 4 een bij voorkeur toe te passen uitvoeringsvorm van de gehoor-
inrichting volgens figuur 4, waarbij een combinatie van arrays wordt
toegepast;

1 Figuur 5 een polair diagram van een gecombineerde array van figuur 1 bij 500 en 1000 Hz;

2 Figuur 6 een polair diagram van een uitvoeringsvorm van figuur 1 bij 2000 en 4000 Hz; en

5 Figuur 7 de richtingindex van de uitvoeringsvorm van figuur 4 als functie van de frequentie.

De gehoorinrichting volgens de uitvinding omvat een array van microfoons. Deze array kan elke vorm hebben.

10 Deze array heeft twee array-uitgangssignalen die elk worden toegevoerd aan een eigen overdrachtstraject naar het linker- resp. 15 rechter oor van de slechthorende. In dit overdrachtstraject zijn op gebruikelijke wijze een versterking en omzetting van het elektrische signaal uit de array, naar geluidstrillingen toegepast.

15 De array heeft twee onder een hoek ten opzichte van elkaar verlopende hoofdgevoelighedsinrichtingen, een en ander zodanig dat het eerste array-uitgangssignaal in hoofdzaak een weerspiegeling is van het geluid uit de eerste hoofdgevoelighedsinrichting, terwijl het tweede array-uitgangssignaal in hoofdzaak het geluid uit de tweede hoofdgevoelighedsinrichting voorstelt. Hierdoor luistert het linker 20 oor als het ware in een beperkte eerste hoofdgevoelighedsrichting, terwijl het rechter oor in de tweede hoofdgevoelighedsrichting luistert.

25 De bij de array-uitgangssignalen behorende hoofdgevoelighedsrichtingen kunnen worden bereikt door focussering of bundelvorming van de microfoonsignalen.

De array van microfoons kan op eenvoudige wijze worden bevestigd op een brilmontuur. In figuur 1 is een uitvoeringsvorm van een array van microfoons op de voorzijde van het brillenmontuur getoond, waarbij bundelvorming is toegepast.

30 In figuur 1 is met het verwijzingsnummer 1 schematisch het hoofd van een slechthorende aangegeven. Zijn opgezette bril is schematisch met rechte lijnen weergegeven, welke bril op gebruikelijke wijze bestaat uit een voorzijde 2 en twee brillenpoten of veren 3, 4.

35 Voorts zijn in figuur 1 de hoofdlobbe 5 voor het linker oor en de hoofdlobbe 6 voor het rechter oor als ellipsen schematisch weergegeven. Deze hoofdlobben staan onder een hoek ten opzichte van elkaar en ten opzichte van de hoofdas 7 van de bril.

Door de hierboven toegepaste hoofdlobben en de gescheiden toevoeging daarvan aan de oren wordt afhankelijk van de plaats van de geluidsbron en ook voor de ruis kunstmatig een verschil tussen het niveau van de array-uitgangssignalen geïntroduceerd. Door dit kunstmatige verschil in de niveaus van de array-uitgangssignalen kan de slechthorende de geluidsbron lokaliseren, echter is gebleken dat dit verschil bovendien de verstaanbaarheid van spraak met ruis verbetert.

Het plaatsen van de array van microfoons op een of beide brilpoten heeft ook voordeel.

10 De toevoeging van de array-uitgangssignalen aan de daarbij behorende hoofdlobben van de array kan op eenvoudige wijze worden bereikt door middel van een zogenaamde parallel- of serie-uitvoering.

Bij de parallel-uitvoering omvatten de middelen voor het afleiden van de array-uitgangssignalen een sommeerinrichting, waarbij aan 15 de ingangen daarvan de microfoonuitgangssignalen via een respectieve al dan niet frequentie-afhankelijke weegfactorinrichting worden toegevoerd. Aan de uitgang van de sommeerinrichting kan dan een array-uitgangssignaal worden afgenoem. Door dimensionering van de weegfactorinrichtingen kan een bij het betreffende array-uitgangssignaal behorende hoofdgevoelighedsrichting worden verkregen.

Bij de zogenaamde serie-uitvoering bevatten de middelen voor 25 het afleiden van de array-uitgangssignalen een aantal sommeerinrichtingen en weegfactorinrichtingen, waarbij de weegfactorinrichtingen telkens in serie zijn geschakeld met de ingang en uitgang van de sommeerinrichtingen. Daarbij is de ene buitenste microfoon verbonden met een ingang van een weegfactorinrichting, waarvan de uitgang dan op een ingang van een sommeerinrichting is aangesloten. De aan de genoemde buitenste microfoon grenzende microfoon is met zijn uitgang met de ingang van de sommeerinrichting verbonden. De uitgang van de sommeer-30 inrichting is met de ingang van een volgende weegfactorinrichting verbonden, waarvan de uitgang in verbinding staat met de ingang van een volgende sommeerinrichting. Met de andere ingang van deze sommeer- inrichting is weer de uitgang van de volgende microfoon verbonden.

Deze configuratie wordt voortgezet tot en met de andere buitenste microfoon van de array. Een array-uitgangssignaal, bijvoorbeeld 35 het linker-oorsignaal kan worden afgenoem van de uitgang van de laatste sommeerinrichting, waarvan de ingang met de uitgang van de laatste genoemde buitenste microfoon is verbonden. Het zou ook mogelijk kunnen

zijn het array-uitgangssignaal via een verdere weegfactorinrichting af te leiden van de uitgang van de genoemde laatste sommeerinrichting.

Bij een verdere uitwerking omvat de weegfactorinrichting een vertragingsinrichting, eventueel aangevuld met een amplitude-instel-
5 inrichting.

Bij een andere uitwerking bestaat de weegfactorinrichting uit een fase-instelinrichting eventueel aangevuld met een amplitude-in-
stelinrichting.

In figuur 2 is de parallel-uitvoering met vertragingsinrichtin-
10 gen getoond. Rechts van figuur 2 zijn de microfoons 8, 9, 10, 11 en 12
getoond, die in de tekening zijn verbonden door een lijn om aan te
geven dat het hier om een array gaat. De uitgangen van de microfoons
8-12 zijn verbonden met de ingangen van de respectieve vertragings-
inrichtingen 13, 14, 15, 16 en 17. De uitgangen van deze vertragings-
15 inrichtingen 13-17 staan in verbinding met de ingangen van de sommeer-
inrichting 18, aan de uitgang waarvan een array-uitgangssignaal kan
worden afgeleid, bijvoorbeeld een linker-oorsignaal. In elk traject
tussen een microfoon en een ingang van de sommeerinrichting kan op
niet getoonde wijze naar wens een amplitude-instelinrichting worden
20 opgenomen, die gevormd kan zijn door een versterker of verzwakker. Bij
voorkeur wordt het signaal van de n^{de} microfoon vertraagd met een
tijdsperiode $n\tau_t$. In figuur 2 is getoond, dat het uitgangssignaal van
de microfoon 8 met een vertragingstijd 0 aan de ingang van de sommeer-
inrichting 18 wordt toegevoerd, terwijl dat van de microfoon 9 met een
25 tijervertraging τ_t aan een volgende ingang van de sommeerinrichting 18
wordt toegevoerd. Het overeenkomstige geldt voor de microfoons 10, 11
en 12; dat wil zeggen vertragingstijden van $2\tau_t$ respectievelijk $3\tau_t$
respectievelijk $4\tau_t$. De vertragingstijd τ_t is zodanig gekozen, dat
geluid afkomstig van de richting die een hoek maakt van θ ten opzichte
30 van de hoofdas van de array in fase wordt gesommeerd. Er geldt dan:

$$\tau_t = d \sin \theta / c, \text{ waarbij } d \text{ de afstand is tussen twee microfoons en } c \text{ de golfvoortplantingsnelheid is.}$$

Voor het rechter-oorsignaal kan een soortgelijke opstelling worden ontworpen.

35 In figuur 3 is de zogenaamde serie-uitvoering met vertragings-
inrichtingen getoond.

Bij deze getoonde uitvoeringsvorm wordt een serieschakeling van
4 vertragingsinrichtingen 18-21 en 4 sommeerinrichtingen 22-24 toege-

past. De vertragingsinrichtingen en sommeerinrichtingen zijn om en om in serie geschakeld. De microfoon 12 is aangesloten op de ingang van de vertragingsinrichting 21, terwijl de uitgangen van de microfoons 8-11 zijn verbonden met de respectieve sommeerinrichtingen 23-26.

5 Ook bij deze uitvoeringsvorm wordt het signaal uit de microfoon 12 vertraagd met een tijdsvertraging van 4 maal τ_t , wanneer elke vertragingsinrichting een vertraging van τ_t voortbrengt. Het uitgangssignaal van de microfoon 11 wordt na optelling in de sommeerinrichting 26 vertraagd met een tijdsvertraging van 3 maal τ_t . Het overeenkomstige geldt voor de microfoons 9 en 10. Het uitgangssignaal van de microfoon 8 wordt niet vertraagd. Indien gewenst kan achter de sommeerinrichting 23 nog een vertragingsinrichting worden opgenomen.

10 15 Ook bij deze zogenaamde serie-uitvoering kunnen telkens amplitude-instelinrichtingen in de vorm van versterkers of verzwakkers in de serieketen worden opgenomen, elk behorend bij een uitgangssignaal van een bepaalde microfoon van de array. Als vertragingsinrichting kan op eenvoudige wijze een alles doorlatend filter van de eerste orde worden toegepast, die kan worden ingesteld door middel van een potentiometer.

20 25 Als praktische uitvoeringsvorm kan een microfonenarray van 14 cm lengte worden toegepast. Door de hierboven beschreven middelen voor het afleiden van de uitgangssignalen van de microfoons die elk behoren bij een hoofdgevoelighedsrichting, kunnen voor de microfoons hele eenvoudige rondom gevoelige microfoons worden gebruikt. Desgewenst kunnen cardioide-microfoons worden toegepast om extra richtinggevoelighed te verkrijgen.

30 Wanneer de hoek tussen de twee hoofdgevoelighedsrichtingen of hoofdlobben groter wordt, zal het verschil tussen de hoorsignalen, t.w. het interoor-niveauverschil groter worden. Daardoor zal in het algemeen de localiseerbaarheid beter worden.

Naarmate de genoemde hoek tussen de hoofdlobben groter wordt, zal echter de verzwakking van een geluidssignaal in de richting van een hoofdas van de array echter toenemen. De keuze van de hoek tussen de hoofdlobben zal dus in de praktijk een compromis zijn tussen een goed interoor-niveauverschil en een acceptabele verzwakking in de hoofdrichting van de array. Deze keuze wordt bij voorkeur proefondervindelijk bepaald.

Voorts wordt bij vergroting van de hoek tussen de hoofdlobben, na een bepaalde hoek de hoofdlobben elk gesplitst in twee lobben. Dit verschijnsel kan worden vermeden door toepassing van een amplitude-weegfunctie voor de microfoonsignalen.

5 Bij een bij voorkeur toe te passen uitvoeringsvorm van de uitvinding wordt een array aan de voorzijde van het brillenmontuur en twee arrays elk op een brillenpoot bevestigd toegepast. Een voorbeeld met elf microfoons is in figuur 4 getoond. De microfoons 26, 27 en 28, die de linker array vormen, zijn bevestigd op de linker brillenpoot en 10 de microfoons 34, 35 en 36 van de rechter array op de rechter brillenpoot. De microfoons 29-33 zijn aan de voorzijde van het brillenmontuur bevestigd.

De signalen uit de microfoons 29-33 worden op de hierboven beschreven wijze toegevoerd aan de overdrachtstrajecten voor het linker respectievelijk rechter oor. De signalen uit de microfoons 26, 27, 15 28 worden gekoppeld aan het overdrachtstraject voor het linker oor, terwijl de signalen uit de microfoons 34-36 via het andere overdrachtstraject aan het rechter oor worden toegevoerd.

Bij hoge frequenties wordt een interoor-niveauverschil ge-20 creëerd met behulp van de bundelvorming van de array aan de voorzijde van het brillenmontuur en is de schaduwwerking van de arrays op de brillenpoten van invloed. Bij lage frequenties wordt er een interoor-25 tijdverschil gecreëerd door middel van de arrays op de brillenpoten. Onder interoor-tijdverschil wordt het verschil in aankomsttijd tussen de signalen bij de oren als gevolg van het verschil in voortplantingstijd bedoeld.

Figuur 5 toont de richtingskarakteristiek van de arrays-combinatie van figuur 4 bij een frequentie van 500 Hz, aangegeven door een streep punt lijn en bij 1000 Hz aangegeven door een getrokken lijn. De 30 richtingskarakteristiek van figuur 5 wordt verkregen met de arrays op de brillenpoten. De array aan de voorzijde van de bril staat dus uit, aangezien zij laagfrequent weinig extra richtwerking oplevert. Op deze wijze wordt dus een interoor-tijdsverschil gecreëerd.

In figuur 6 zijn de richtkarakteristieken van de arrays-combinatie getoond bij 2000 Hz, aangegeven met een streep-punt-lijn en bij 4000 Hz, aangegeven met een getrokken lijn. In het midden en hoogfrequent gedeelte van het hoorbare geluidsbereik zijn de hoofdlobben

op 11° gericht, zodat er weer een interoor-niveauverschil wordt gecreeëerd.

5 Figuur 7 toont de directiviteitsindex als functie van de frequentie voor 3 geoptimaliseerde frequentiegebieden. De getrokken lijn geldt voor de lage frequenties, geoptimaliseerd bij 500 Hz. De streeplijn geldt voor optimalisatie bij 4000 Hz en de streep-punt-lijn voor optimalisatie bij 2300 Hz.

10 Opgemerkt wordt nog dat ook met de arrays op de brillenpoten een interoor-niveauverschil kan worden voortgebracht zoals bij de array aan de voorzijde van het brillenmontuur.

CONCLUSIES

1. Gehoorinrichting voor het verbeteren van de verstaanbaarheid voor slechthorenden, omvattende een array van microfoons, waarvan de 5 elektrische uitgangssignalen worden toegevoerd aan tenminste één bij een oor behorend overdrachtstraject, met het kenmerk, dat middelen aanwezig zijn om uit de uitgangssignalen van de microfoons twee array-uitgangssignalen af te leiden, waarbij de array twee onder een hoek 10 ten opzichte van elkaar verlopende hoofdgevoelighedsrichtingen heeft, die elk zijn toegevoegd aan een array-uitgangssignaal en dat elk array-uitgangssignaal wordt toegevoerd aan een eigen bij een oor van een slechthorende behorend overdrachtstraject.

2. Gehoorinrichting volgens conclusie 1, met het kenmerk, dat de array aan de voorzijde van een bril is aangebracht.

15 3. Gehoorinrichting volgens conclusie 1 of 2, met het kenmerk, dat de array op een brillenpoot is aangebracht.

4. Gehoorinrichting volgens conclusie 2, met het kenmerk, dat elke brillenpoot is voorzien van een array van microfoons en dat de uitgangssignalen van deze arrays elk aan het ene respectievelijk 20 andere overdrachtstraject worden toegevoerd.

5. Gehoorinrichting volgens conclusie 1, 2, 3 of 4, met het kenmerk, dat de middelen voor het afleiden van de array-uitgangssignalen een sommeerinrichting bevatten, aan de uitgang waarvan een array-uitgangssignaal afneembaar is en aan de ingangen waarvan de microfoonuit- 25 gangssignalen via een respectieve weegfactorinrichting worden toegevoerd.

6. Gehoorinrichting volgens conclusie 1, 2, 3 of 4, met het kenmerk, dat de middelen voor het afleiden van de array-uitgangssignalen een serieschakeling van een aantal sommeerinrichtingen en weegfactor- 30 inrichtingen bevatten, waarbij de uitgangen van de tussen de twee buitenste microfoons opgestelde microfoons op de andere niet met een weegfactorinrichting verbonden ingangen van de sommeerinrichtingen zijn aangesloten, dat een van de buitenste microfoons van de array via een weegfactorinrichting op de ingang van de bij de aangrenzende 35 microfoon behorende sommeerinrichting is aangesloten en dat met de uitgang van de sommeerinrichting van de microfoon, die grenst aan de andere buitenste microfoon, de ingang van een weegfactorinrichting is verbonden, op de uitgang waarvan de ene ingang van een sommeerinrich-

ting is aangesloten, waarbij met de andere ingang van de sommeer-
inrichting de uitgang van de laatstgenoemde microfoon is verbonden en
aan de uitgang van de sommeerinrichting een array-uitgangssignaal kan
worden afgeleid.

5 7. Gehoorinrichting volgens conclusie 6, met het kenmerk, dat het
array-uitgangssignaal via een verdere weegfactorinrichting wordt afge-
leid.

8. Gehoorinrichting volgens conclusie 5, 6 of 7, met het kenmerk,
dat de weegfactorinrichting een vertragingsinrichting omvat.

10 9. Gehoorinrichting volgens conclusie 8, met het kenmerk, dat de
weegfactorinrichting een amplitude-instelinrichting omvat.

10. Gehoorinrichting volgens conclusie 5, 6 of 7, met het ken-
merk, dat de weegfactorinrichting een fase-instelinrichting omvat.

11. Gehoorinrichting volgens conclusie 10, met het kenmerk, dat
15 de weegfactorinrichting een amplitude-instelinrichting omvat.

UITTREKSEL

Gehoorinrichting voor het verbeteren van de verstaanbaarheid voor slechthorenden, omvattende een array van microfoons, waarvan de
5 elektrische uitgangssignalen worden toegevoerd aan tenminste één bij een oor behorend overdrachtstraject. Er zijn middelen aanwezig om uit de uitgangssignalen van de microfoons twee array-uitgangssignalen af te leiden, waarbij de array twee onder een hoek ten opzichte van elkaar verlopende hoofdgevoeligheidsrichtingen heeft, die elk zijn
10 toegevoegd aan een array-uitgangssignaal. Elk array-uitgangssignaal wordt toegevoerd aan een eigen bij een oor van een slechthorende behorend overdrachtstraject.

Fig -1

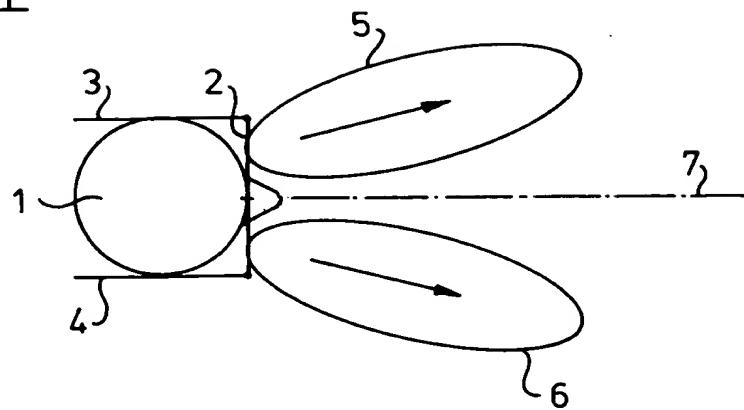


Fig -2

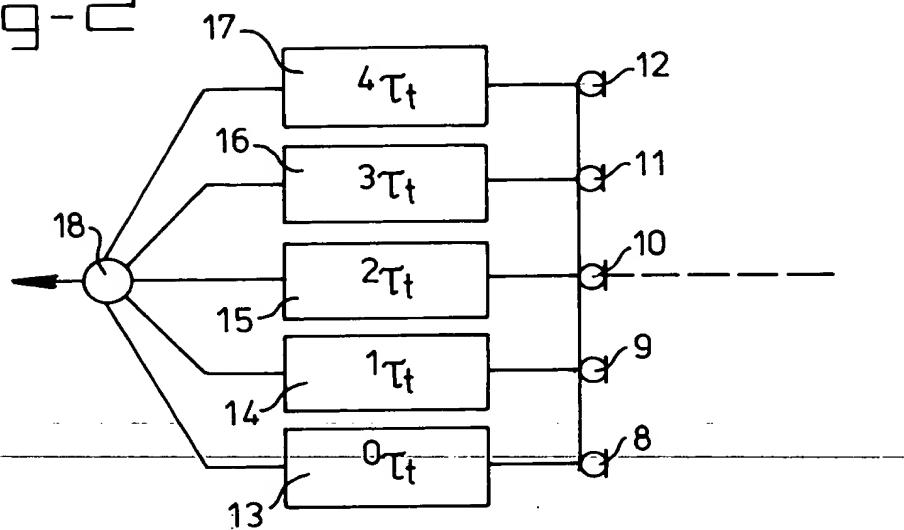
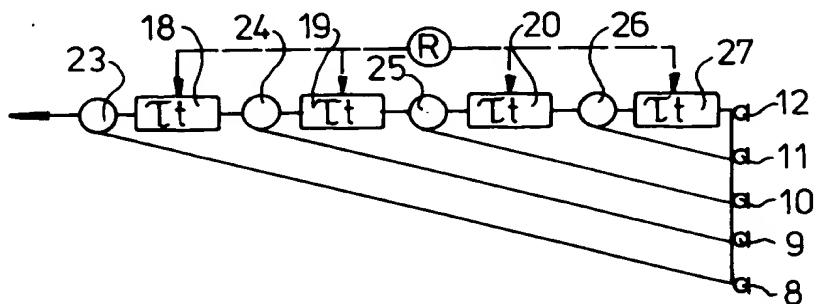


Fig -3



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Fig - 4

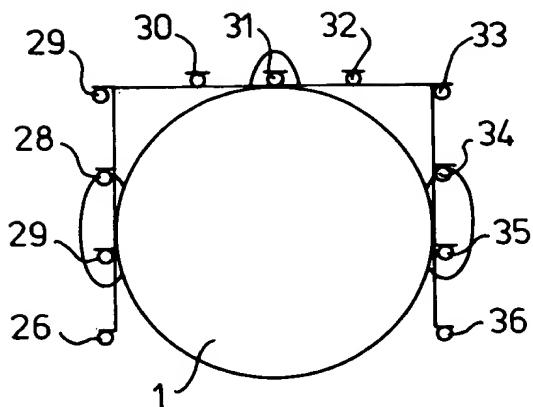


Fig - 5

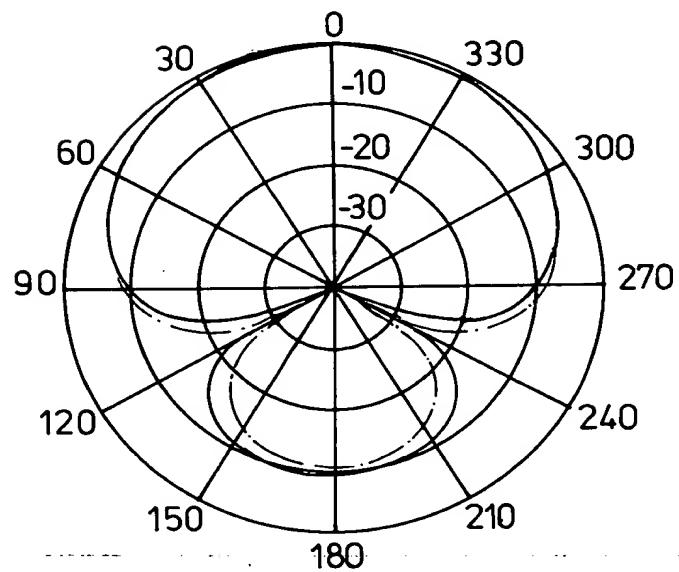


Fig - 6

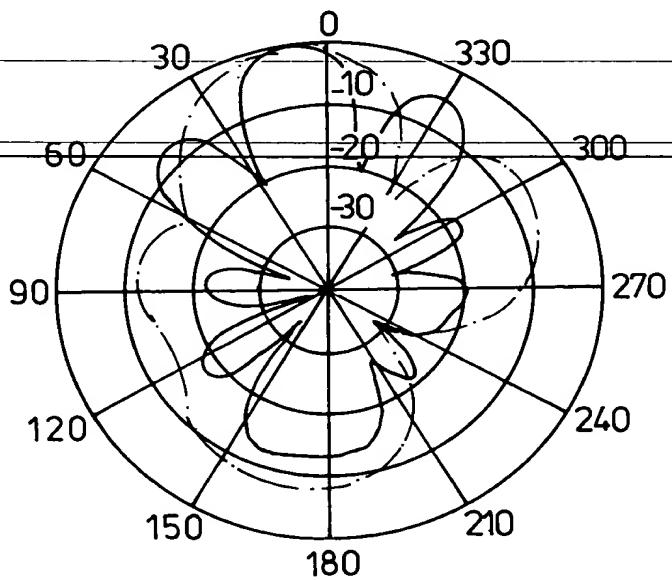
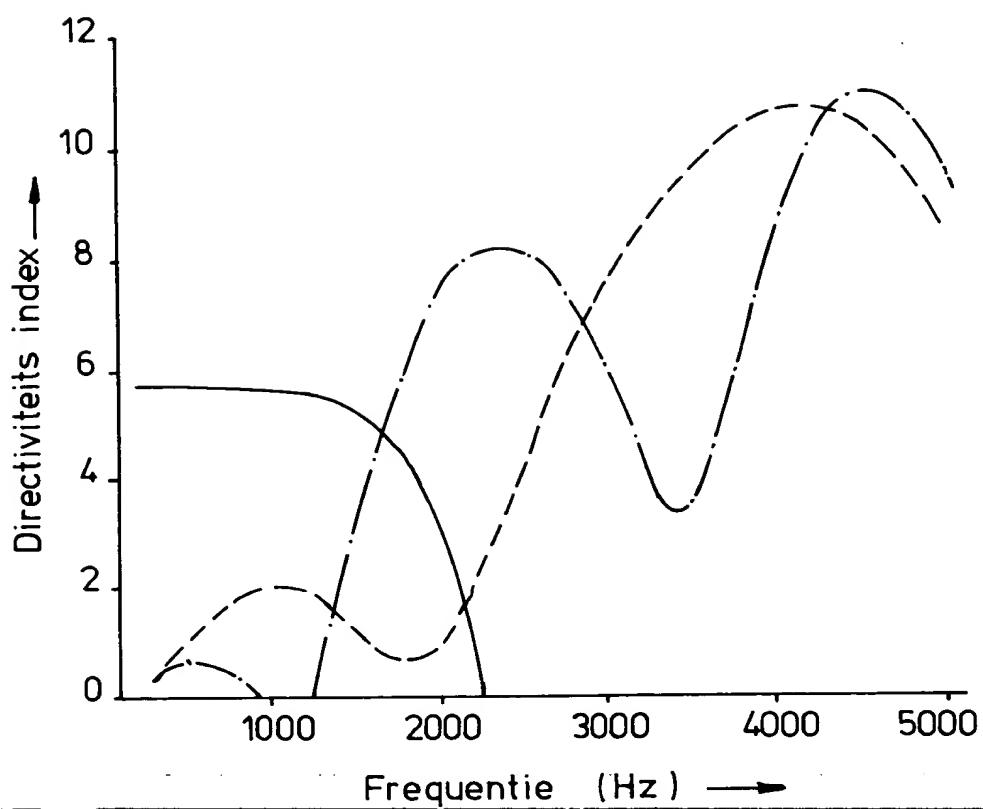


fig - 7



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PATENT COOPERATION TREATY

REC'D 27 JAN 2000

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference BO 41592	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/NL98/00602	International filing date (day/month/year) 20/10/1998	Priority date (day/month/year) 20/10/1997
International Patent Classification (IPC) or national classification and IPC H04R25/00		
Applicant TECHNISCHE UNIVERSITEIT DELFT et al.		
<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 4 sheets, including this cover sheet.</p> <p><input checked="" type="checkbox"/> This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of 4 sheets.</p>		
<p>3. This report contains indications relating to the following items:</p> <p>I <input checked="" type="checkbox"/> Basis of the report II <input type="checkbox"/> Priority III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability IV <input type="checkbox"/> Lack of unity of invention V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement VI <input type="checkbox"/> Certain documents cited VII <input type="checkbox"/> Certain defects in the international application VIII <input type="checkbox"/> Certain observations on the international application</p>		

Date of submission of the demand 18/05/1999	Date of completion of this report 25. 01. 00
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Emst, C Telephone No. +49 89 2399 8958



**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/NL98/00602

I. Basis of the report

1. This report has been drawn on the basis of (*substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.*):

Description, pages:

2-8	as originally filed	
1	with telefax of	14/01/2000

Claims, No.:

1-11	with telefax of	14/01/2000
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Drawings, sheets:

1/3,3/3	as originally filed	
2/3	with telefax of	14/01/2000

2. The amendments have resulted in the cancellation of:

the description, pages:
 the claims, Nos.:
 the drawings, sheets:

3. This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

4. Additional observations, if necessary:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/NL98/00602

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N) Yes: Claims 1 - 11
 No: Claims

Inventive step (IS) Yes: Claims 1 - 11
 No: Claims

Industrial applicability (IA) Yes: Claims 1 - 11
 No: Claims

2. Citations and explanations

see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/NL98/00602

Section V

The closest prior art is US-A-4 956 867 which is mentioned on page 1 of the present application. This document describes an apparatus for suppressing signals from noise sources surrounding a target source.

The claimed device according to present claim 1 differs from the known device in that means are provided for deriving two array output signals from the output signals of the microphones, the array having two main sensitivity directions running at an angle with respect to the main axis of the array, and each of which is associated to an array output signal, and in that each array output signal is fed to its own transmission path, one for the left and the other to the right ear of a person who is hard of hearing.

Since these features are neither known nor suggested by the prior art known from the search report, claim 1 satisfies the requirements of Articles 33(2) and 33(3) PCT.

Claims 2 to 11

These dependent claims disclose further embodiments of the hearing aid according to claim 1. Therefore claims 2 to 11 in combination with claim 1 meet the requirements of the PCT in respect of novelty (Article 33(2) PCT) and inventive step (Article 33(3) PCT).

Hearing aid for improving the hearing ability of the hard of hearing

5 The invention relates to a hearing aid for improving the hearing ability of the hard of hearing, comprising an array of microphones, the electrical output signals of which are fed to at least one transmission path belonging to an ear.

10 A device of this type is known from the article entitled "Development of a directional hearing instrument based on array technology" published in the "Journal of the Acoustical Society of America", Vol. 94, Edition 2, Pt. 1, pages 785-798, August 1993.

15 It is generally known that loss of hearing in people can be compensated for by means of a hearing aid, in which amplification of the received sound is used. In environments with background noise, for example when several people are speaking at once, as is the case at a cocktail party, the hearing aid amplifies both the desired speech and the noise, as a result of which the ability to hear is not improved.

20 15 In the abovementioned article the authors describe an improvement proposal. The hearing aid disclosed in the article consists of an array of, for example, five directional microphones, as a result of which it is possible for the person who is hard of hearing to understand someone who is speaking directly opposite him or her. The background noise which emanates from other directions is suppressed by the array.

25 20 From US-A-4 956 867 an apparatus for suppressing signals from noise sources surrounding a target source is known. This apparatus comprises a receiving array including two microphones spaced apart by a distance. The outputs of the microphones are combined such that a primary signal channel and a noise signal channel are obtained. The outputs of the channels are subtracted for cancelling the noise from the primary signal channel.

30 25 The aim of the invention is to provide a hearing aid of the type mentioned in the preamble with which the abovementioned disadvantages are avoided and the understandability and the naturalness of the reproduction is improved in a simple manner.

35 Said aim is achieved according to the invention in that means are provided for deriving two array output signals from the output signals of the microphones, the array having two main sensitivity directions running at an angle with respect to the main axis of the array, and each of which is associated to an array output signal, and in that each array output signal is fed to its own transmission path one to the left ear and the other to the right ear of a person who is hard of hearing.

CLAIMS

1. Hearing aid for improving the hearing ability of the hard of hearing, comprising an array of microphones (8-12), the electrical output signals of which are fed to at least one transmission path belonging to an ear, characterised in that means are provided for deriving two array output signals from the output signals of the microphones (8-12; 26-36), the array having two main sensitivity directions (5,6) running at an angle with respect to the main axis of the array, and each of which is associated to an array output signal, and in that each array output signal is fed to its own transmission path, one to the left ear and the other to the right ear of a person who is hard of hearing.
5
2. Hearing aid according to claim 1, characterised in that the array (29-33) is mounted on the front (2) of a pair of spectacles.
3. Hearing aid according to claim 1 or 2, characterised in that the array is mounted on an arm (3,4) of a pair of spectacles.
10
4. Hearing aid according to claim 2, characterised in that each arm (3,4) of the spectacles is provided with an array of microphones and in that the output signals from said arrays are each fed to the one or, respectively, the other transmission path.
5. Hearing aid according to claim 1, 2, 3, or 4, characterised in that the means for deriving the array output signals contain a summing device (18), from the output of which an array output signal can be taken off and to the inputs of which the microphone output signals are fed via a respective weighting factor device (13-17).
20
6. Hearing aid according to claim 1, 2, 3, or 4, characterised in that the means for deriving the array output signals contain a series circuit of a number of summing devices (23, 24, 25, 26) and weighting factor devices (18, 19, 20, 27), the outputs of the microphones (9-11) arranged between the two outermost microphones (8-12) being connected to the other inputs of the summing devices, which other inputs are not connected to a weighting factor device, in that one (12) of the outermost microphones of the array is connected via a weighting factor device (27) to the input of the summing device (26) associated with the adjacent microphone (11) and in that the input of a weighting factor device (18) is connected to the output of the summing device (24) of the microphone adjacent to the other outermost microphone (9), the one input of a summing device (23) being connected to the output of said weighting factor device (18).
25
30

10

the output of the last-mentioned microphone (8) being connected to the other input of the summing device (23) and it being possible to derive an array output signal at the output of the summing device (23).

7. Hearing aid according to claim 6, characterised in that the array output signal is derived via a further weighting factor device.

8. Hearing aid according to claim 5, 6, or 7, characterised in that the weighting factor device (13-17, 18, 19, 20, 27) comprises a delay device.

9. Hearing aid according to claim 8, characterised in that the weighting factor device (13-17, 18, 19, 20, 27) comprises an amplitude-adjustment device.

10. Hearing aid according to claim 5, 6, or 7, characterised in that the weighting factor device (13-17, 18, 19, 27) comprises a phase-adjustment device.

11. Hearing aid according to claim 10, characterised in that the weighting factor device (13-17, 18, 19, 27) comprises an amplitude-adjustment device.

2/3

fig - 4

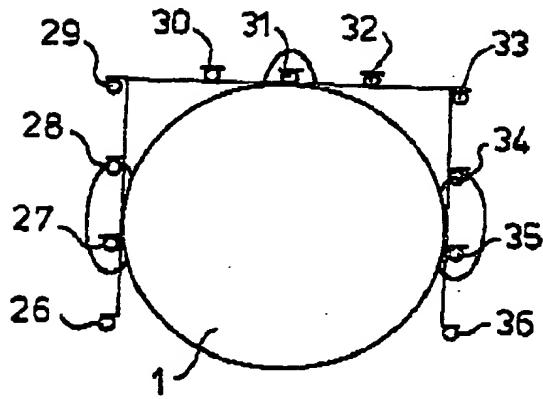


fig - 5

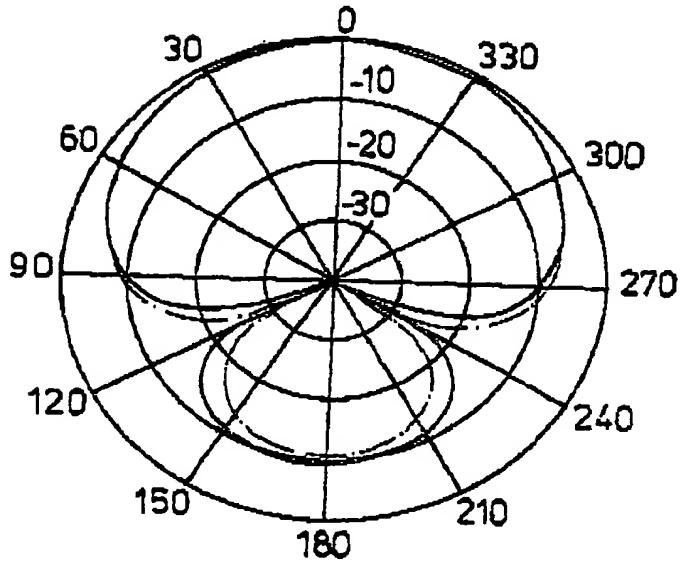
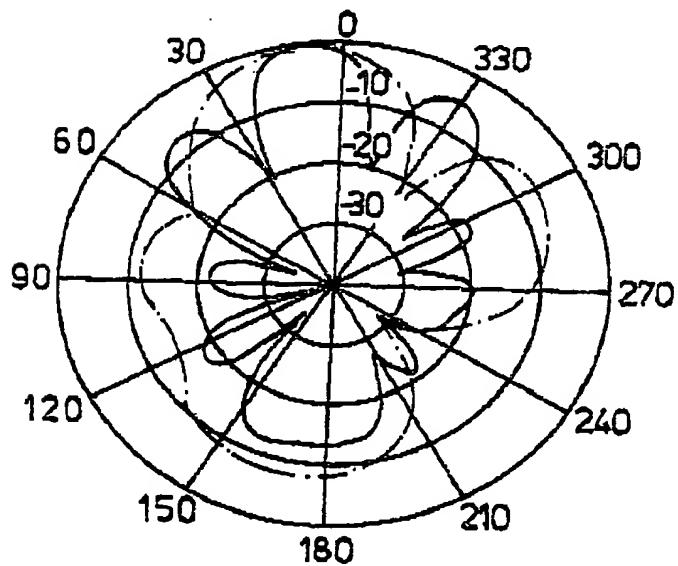


fig - 6



PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference BO 41592	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/NL 98/ 00602	International filing date (day/month/year) 20/10/1998	(Earliest) Priority Date (day/month/year) 20/10/1997
Applicant TECHNISCHE UNIVERSITEIT DELFT et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

It is also accompanied by a copy of each prior art document cited in this report.

1. Certain claims were found unsearchable (see Box I).
2. Unity of invention is lacking (see Box II).
3. The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
 - filed with the international application.
 - furnished by the applicant separately from the international application,
 - but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
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4. With regard to the title, the text is approved as submitted by the applicant
 the text has been established by this Authority to read as follows:
HEARING AID COMPRISING AN ARRAY OF MICROPHONES
5. With regard to the abstract,
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6. The figure of the drawings to be published with the abstract is:

Figure No. 1 as suggested by the applicant. None of the figures.

because the applicant failed to suggest a figure.

because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/NL 98/00602

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 6 H04R25/00 G02C11/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H04R G02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SOEDE W ET AL: "DEVELOPMENT OF A DIRECTIONAL HEARING INSTRUMENT BASED ON ARRAY TECHNOLOGY" JOURNAL OF THE ACOUSTICAL SOCIETY OF AMERICA, vol. 94, no. 2 PART 01, 1 August 1993, pages 785-798, XP000387744 cited in the application see the whole document ---	1
A	US 5 483 599 A (ZAGORSKI MICHAEL A) 9 January 1996 see column 5, line 27 - line 47; figure 8 ---	1
A	US 5 511 128 A (LINDEMANN ERIC) 23 April 1996 see column 2, line 35 - column 4, line 19; figures ---	1
		-/-

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 956 867 A (ZUREK PATRICK M ET AL) 11 September 1990 see column 2, line 12 - column 3, line 14; figures -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/NL 98/00602

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US 5483599	A 09-01-1996	US 5243660 A		07-09-1993
		CA 2097136 A		29-11-1993
US 5511128	A 23-04-1996	AU 1833395 A		08-08-1995
		EP 0740893 A		06-11-1996
		WO 9520305 A		27-07-1995
US 4956867	A 11-09-1990	WO 9013215 A		01-11-1990



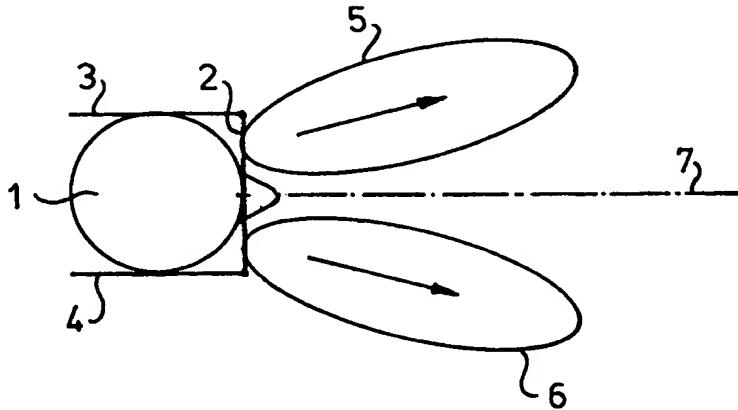
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(51) International Patent Classification ⁶ : H04R 25/00, G02C 11/06		A1	(11) International Publication Number: WO 99/21400
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<p>(21) International Application Number: PCT/NL98/00602</p> <p>(22) International Filing Date: 20 October 1998 (20.10.98)</p> <p>(30) Priority Data: 1007321 20 October 1997 (20.10.97) NL</p> <p>(71) Applicants (for all designated States except US): TECHNISCHE UNIVERSITEIT DELFT [NL/NL]; P.O. Box 5046, NL-2600 GA Delft (NL). STICHTING VOOR DE TECHNISCHE WETENSCHAPPEN [NL/NL]; P.O. Box 3021, NL-3502 GA Utrecht (NL).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (for US only): BOONE, Marinus, Marias [NL/NL]; Voorweg 105A, NL-2715 NG Zoetermeer (NL). BERKHOUT, Augustinus, Johannes [NL/NL]; Nieuwe Parklaan 30, NL-2597 LD Den Haag (NL). MERKS, Ivo, Léon, Diane, Marie [NL/NL]; Dakarhof 56, NL-2622 CR Delft (NL).</p> <p>(74) Agent: DE BRUIJN, Leendert, C.; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS The Hague (NL).</p>			<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report. In English translation (filed in Dutch).</p>

(54) Title: HEARING AID COMPRISING AN ARRAY OF MICROPHONES

(57) Abstract

Hearing aid for improving the hearing ability of the hard of hearing, comprising an array of microphones, the electrical output signals of which are fed to at least one transmission path belonging to an ear. Means are provided for deriving two array output signals from the output signals of the microphones, the array having two main sensitivity directions running at an angle with respect to one another and each of which is associated to an array output signal. Each array output signal is fed to its own transmission path belonging to one ear of a person who is hard of hearing.



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HEARING AID COMPRISING AN ARRAY OF MICROPHONES

The invention relates to a hearing aid for improving the
5 hearing ability of the hard of hearing, comprising an array of
microphones, the electrical output signals of which are fed to
at least one transmission path belonging to an ear.

A device of this type is known from the article entitled
"Development of a directional hearing instrument based on array
10 technology" published in the "Journal of the Acoustical Society
of America", Vol. 94, Edition 2, Pt. 1, pages 785-798, August
1993.

It is generally known that loss of hearing in people can be
compensated for by means of a hearing aid, in which
15 amplification of the received sound is used. In environments
with background noise, for example when several people are
speaking at once, as is the case at a cocktail party, the
hearing aid amplifies both the desired speech and the noise, as
a result of which the ability to hear is not improved.

20 In the abovementioned article the authors describe an
improvement proposal. The hearing aid disclosed in the article
consists of an array of, for example, five directional
microphones, as a result of which it is possible for the person
who is hard of hearing to understand someone who is speaking
25 directly opposite him or her. The background noise which
emanates from other directions is suppressed by the array.

The aim of the invention is to provide a hearing aid of the
type mentioned in the preamble with which the abovementioned
disadvantages are avoided and the understandability and the
30 naturalness of the reproduction is improved in a simple manner.

Said aim is achieved according to the invention in that
means are provided for deriving two array output signals from
the output signals of the microphones, the array having two
main sensitivity directions running at an angle with respect to
35 one another and each of which is associated to an array output
signal, and in that each array output signal is fed to its own
transmission path belonging to one ear of a person who is hard
of hearing.

With this arrangement the signals from the microphones of the array are combined to give a signal for the left ear and a signal for the right ear. The array has two main sensitivity directions or main lobes running at an angle with respect to 5 one another, the left ear signal essentially representing the sound originating from the first main sensitivity direction and the right ear signal representing that from the other main sensitivity direction. The array output signals, that is to say the left ear signal and the right ear signal, are fed via their 10 own transmission path to the left ear and the right ear, respectively. Amplification of the signal and conversion of the electrical signal into a sound signal is employed in said transmission path.

The different main lobes introduce a difference in level 15 between the signals to be fed to the ears. It has been found that it is not only possible to localise sound sources better, but that background noise is also suppressed as a result of the directional effect, as a result of which the understandability of speech is improved despite the existing noise.

20 The array can advantageously be mounted on the front of a spectacle frame and/or on the arms or springs.

In the case of an embodiment which is preferably to be used, each spectacle arm is also provided with an array of 25 microphones, the output signals from the one array being fed to the one transmission path and the output signals from the other array being fed to the other transmission path.

What is achieved by this means is that understandability is improved not only at high frequencies in the audible sound range but also at relatively low frequencies.

30 Further embodiments of the invention are described in the subsidiary claims.

The invention will be explained in more detail below with reference to the drawings. In the drawings:

Figure 1 shows an embodiment of the hearing aid according to 35 the invention;

Figure 2 shows a more detailed embodiment of the hearing aid according to the invention;

Figure 3 shows another embodiment of the hearing aid according

to the invention;

Figure 4 shows an embodiment of the hearing aid according to Figure 4 in which a combination of arrays is used, which embodiment is preferably to be used;

5 Figure 5 shows a polar diagram of a combined array from Figure 1 at 500 and 1000 Hz;

Figure 6 shows a polar diagram of an embodiment from Figure 1 at 2000 and 4000 Hz; and

Figure 7 shows the directional index of the embodiment in
10 Figure 4 as a function of the frequency.

The hearing aid according to the invention comprises an array of microphones. Said array can have any shape.

Said array has two array output signals which are each fed along their own transmission path, one to the left ear and the
15 other to the right ear of the person hard of hearing. In said transmission path amplification and conversion of the electrical signal from the array to sound vibrations are employed in the conventional manner.

The array has two main sensitivity directions running at an
20 angle with respect to one another, the various features being such that the first array output signal is essentially a reflection of the sound from the first main sensitivity direction, whilst the second array output signal essentially represents the sound from the second main sensitivity
25 direction. As a result the left ear as it were listens in a restricted first main sensitivity direction, whilst the right ear listens in the second main sensitivity direction.

The main sensitivity directions associated with the array output signals can be achieved by focusing or bundling the
30 microphone signals.

The array of microphones can be attached in a simple manner to spectacle frames. Figure 1 shows an embodiment of an array of microphones on the front of the spectacle frames, bundling being employed.

35 In Figure 1 the head of a person hard of hearing is indicated diagrammatically by reference numeral 1. The spectacles worn by this person are shown diagrammatically by straight lines, which spectacles consist, in the conventional

manner, of a front 2 and two spectacle arms or springs 3, 4.

The main lobe 5 for the left ear and the main lobe 6 for the right ear are also shown in Figure 1 as ellipses. Said main lobes are at an angle with respect to one another and with 5 respect to the main axis 7 of the spectacles.

As a result of the main lobes used above and the separate assignment thereof to the ears, a difference between the level of the array output signals is artificially introduced depending on the location of the sound source and also for the 10 noise. As a result of said artificial difference in the levels of the array output signals, the person hard of hearing is able to localise the sound source, but it has been found that said difference also improves the understandability of speech in the presence of noise.

15 Positioning the array of microphones on one or both of the spectacle arms is also advantageous.

The association of the array output signals to the associated main lobes of the array can be achieved in a simple manner by means of a so-called parallel or serial construction.

20 In the case of the parallel construction, the means for deriving the array output signals comprise a summing device, the microphone output signals being fed to the inputs of said summing device via a respective frequency-dependent or frequency-independent weighting factor device. An array output 25 signal can then be taken off at the output of the summing device. A main sensitivity direction associated with the relevant array output signal can be obtained by sizing the weighting factor devices.

In the case of the so-called serial construction, the means 30 for deriving the array output signals contain a number of summing devices and weighting factor devices, the weighting factor devices in each case being connected in series with the input and output of the summing devices. With this arrangement one outermost microphone is connected to an input of a 35 weighting factor device, the output of which is then connected to an input of a summing device. The output of the microphone adjacent to the said outermost microphone is connected to the input of the summing device. The output of the summing device

is connected to the input of the next weighting factor device, the output of which is connected to the input of the next summing device. The output of the next microphone is, in turn, connected to the other input of this summing device.

5 This configuration is continued as far as the other outermost microphone of the array. An array output signal, for example the left ear signal, can be taken off from the output of the last summing device, the input of which is connected to the output of the last-mentioned outermost microphone. It could
10 also be possible to derive the array output signal from the output of the said last summing device via a further weighting factor device.

In a further development, the weighting factor device comprises a delay device, optionally supplemented by an
15 amplitude-adjustment device.

In another development, the weighting factor device consists of a phase adjustment device, optionally supplemented by an amplitude-adjustment device.

Figure 2 shows the parallel construction with delay
20 devices. The microphones 8, 9, 10, 11 and 12 are shown on the right of Figure 2, which microphones are connected by a line in the drawing to indicate that it is an array that is concerned here. The outputs of the microphones 8-12 are connected to the inputs of the respective delay devices 13, 14, 15, 16 and 17.
25 The outputs of said delay devices 13-17 are connected to the inputs of the summing device 18, at the output of which an array output signal, for example a left ear signal, can be derived. An amplitude-adjustment device, which can consist of an amplifier or a attenuator, can be incorporated, in a manner
30 which is not shown, in each path between a microphone and an input of the summing device. Preferably, the signal of the n^{th} microphone is delayed by a period $n\tau_t$. Figure 2 shows that the output signal from the microphone 8 is fed to the input of the summing device 18 with a delay period 0, whilst the output
35 signal from the microphone 9 is fed to the next input of the summing device 18 with a delay τ_t . The corresponding delays apply in the case of the microphones 10, 11 and 12; that is to say delay periods of $2\tau_t$, $3\tau_t$ and $4\tau_t$ respectively. The delay

period τ_t is chosen such that sound emanating from the direction which makes an angle of θ with respect to the main axis of the array is summed in phase. Then: $\tau_t = d \sin \theta / c$, where d is the distance between two microphones and c is the
5 wave propagation rate.

A similar arrangement can be designed for the right ear signal.

Figure 3 shows the so-called serial construction with delay devices.

10 In the case of this embodiment shown a series circuit of 4 delay devices 18-21 and 4 summing devices 22-24 is used. The delay devices and summing devices are connected alternately in series. The microphone 12 is connected to the input of the delay device 21, whilst the outputs of the microphones 8-11 are
15 connected to the respective summing devices 23-26.

With this embodiment as well the signal from the microphone 12 is delayed by a delay period of 4 times τ_t , if each delay device produces a delay of τ_t . After adding in the summing device 26, the output signal from the microphone 11 is delayed
20 by a delay period of 3 times τ_t . Corresponding delays apply in respect of the microphones 9 and 10. The output signal from the microphone 8 is not delayed. If desired, a further delay device can be incorporated behind the summing device 23.

With this so-called serial construction as well it is
25 possible to incorporate amplitude-adjustment devices in the form of amplifiers or attenuators in each part of the series circuit, each amplitude-adjustment device being associated with an output signal from a specific microphone in the array. The delay device used can simply be an all-pass filter of the first
30 order, which can be adjusted by means of a potentiometer.

A microphone array 14 cm long can be used as a practical embodiment. As a consequence of the means described above for deriving the output signals from the microphones which are each associated with one main sensitivity direction, the microphones
35 used can be very simple microphones of omnidirectional sensitivity. If desired, cardioid microphones can be used to obtain additional directional sensitivity.

If the angle between the two main sensitivity directions or

main lobes becomes greater, the difference between the audible signals, i.e. the inter-ear level difference, will become greater. Consequently the localisability will in general become better.

5 However, as the said angle between the main lobes becomes greater, the attenuation of a sound signal will increase in the direction of a main axis of the array. The choice of the angle between the main lobes will thus, in practice, be a compromise between a good inter-ear level difference and an acceptable 10 attenuation in the main direction of the array. This choice 15 will preferably be determined experimentally.

Furthermore, on enlarging the angle between the main lobes, the main lobes will each be split into two lobes beyond a certain angle. This phenomenon can be avoided by use of an 15 amplitude-weighting function for the microphone signals.

In the case of an embodiment of the invention that is preferably to be used, an array attached to the front of the spectacle frames and two arrays, each attached to one arm of the spectacles, are used. An example with eleven microphones is 20 shown in Figure 4. The microphones 26, 27 and 28, which form the left array, are attached to the left arm of the spectacles and the microphones 34, 35 and 36 of the right array are attached to the right arm of the spectacles. The microphones 29-33 are attached to the front of the spectacle frames.

25 The signals from the microphones 29-33 are fed in the manner described above to the transmission paths for the left and the right ear, respectively. The signals from the microphones 26, 27, 28 are coupled to the transmission path for the left ear, whilst the signals from the microphones 34-36 are 30 fed via the other transmission path to the right ear.

At high frequencies an inter-ear level difference is created with the aid of bundling the array at the front of the spectacle frames and the shadow effect of the arrays on the arms of the spectacles has an influence. At low frequencies an 35 inter-ear time difference is created by means of the arrays on the arms of the spectacles. An inter-ear time difference is defined as the difference in arrival time between the signals at the ears as a consequence of the difference in propagation

time.

Figure 5 shows the directional characteristics of the combination of arrays in Figure 4 at a frequency of 500 Hz, indicated by a dash-and-dot line, and at 1000 Hz, indicated by 5 a continuous line. The directional characteristics in Figure 5 are obtained with the arrays on the arms of the spectacles. The array on the front of the spectacles is thus switched off since it yields little additional directional effect at low frequencies. In this way an inter-ear time difference is thus 10 created.

Figure 6 shows the directional characteristics of the combination of arrays at 2000 Hz, indicated by a dash-and-dot line, 2 and at 4000 Hz, indicated by a continuous line. In the mid and high frequency region of the audible sound range the 15 main lobes are directed at 11°, so that once again an inter-ear level difference is created.

Figure 7 shows the directivity index as a function of the frequency for 3 optimised frequency ranges. The continuous line applies for the low frequencies, optimised at 500 Hz. The 20 broken line applies for optimisation at 4000 Hz and the dash-and-dot line for optimisation at 2300 Hz.

It is also pointed out that an inter-ear level difference can also be produced with the arrays on the arms of the spectacles as with the array on the front of the spectacle 25 frames.

CLAIMS

1. Hearing aid for improving the hearing ability of the hard of hearing, comprising an array of microphones, the 5 electrical output signals of which are fed to at least one transmission path belonging to an ear, characterised in that means are provided for deriving two array output signals from the output signals of the microphones, the array having two main sensitivity directions running at an angle with respect to 10 one another and each of which is associated to an array output signal, and in that each array output signal is fed to its own transmission path belonging to one ear of a person who is hard of hearing.

2. Hearing aid according to Claim 1, characterised in that 15 the array is mounted on the front of a pair of spectacles.

3. Hearing aid according to Claim 1 or 2, characterised in that the array is mounted on an arm of a pair of spectacles.

4. Hearing aid according to Claim 2, characterised in that each arm of the spectacles is provided with an array of 20 microphones and in that the output signals from said arrays are each fed to the one or, respectively, the other transmission path.

5. Hearing aid according to Claim 1, 2, 3, or 4, characterised in that the means for deriving the array output 25 signals contain a summing device, from the output of which an array output signal can be taken off and to the inputs of which the microphone output signals are fed via a respective weighting factor device.

6. Hearing aid according to Claim 1, 2, 3 or 4, 30 characterised in that the means for deriving the array output signals contain a series circuit of a number of summing devices and weighting factor devices, the outputs of the microphones arranged between the two outermost microphones being connected to the other inputs of the summing devices, which other inputs 35 are not connected to a weighting factor device, in that one of the outermost microphones of the array is connected via a weighting factor device to the input of the summing device associated with the adjacent microphone and in that the input

of a weighting factor device is connected to the output of the summing device of the microphone adjacent to the other outermost microphone, the one input of a summing device being connected to the output of said weighting factor device, the 5 output of the last-mentioned microphone being connected to the other input of the summing device and it being possible to derive an array output signal at the output of the summing device.

7. Hearing aid according to Claim 6, characterised in that 10 the array output signal is derived via a further weighting factor device.

8. Hearing aid according to Claim 5, 6 or 7, characterised in that the weighting factor device comprises a delay device.

9. Hearing aid according to Claim 8, characterised in that 15 the weighting factor device comprises an amplitude-adjustment device.

10. Hearing aid according to Claim 5, 6 or 7, characterised in that the weighting factor device comprises a phase-adjustment device.

20 11. Hearing aid according to Claim 10, characterised in that the weighting factor device comprises an amplitude-adjustment device.

fig -1

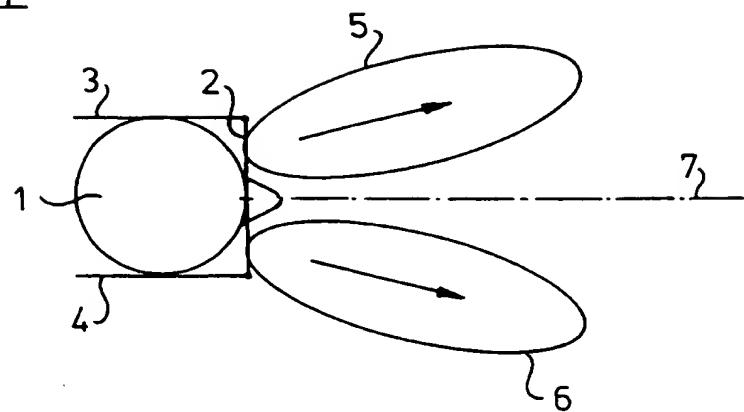


fig -2

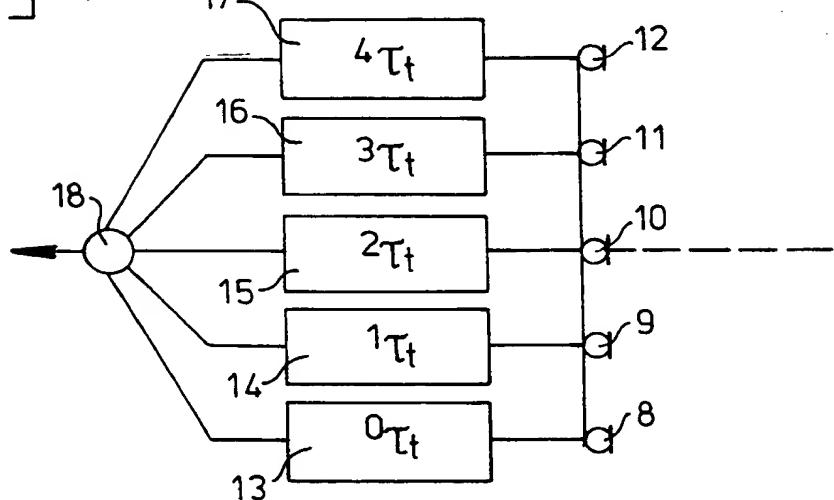
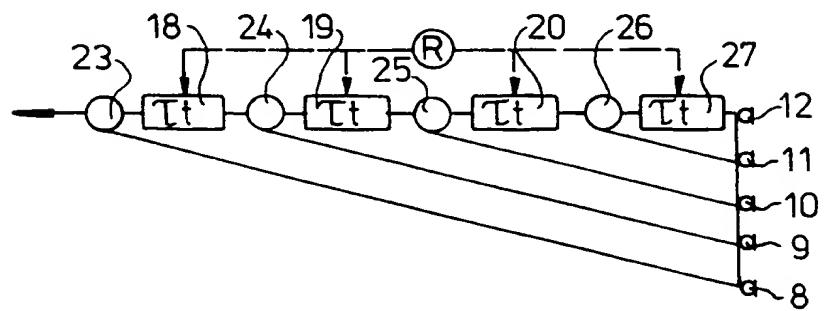


fig -3



2/3

Fig - 4

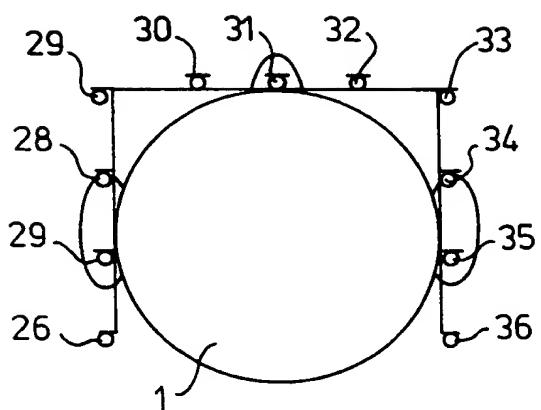


Fig - 5

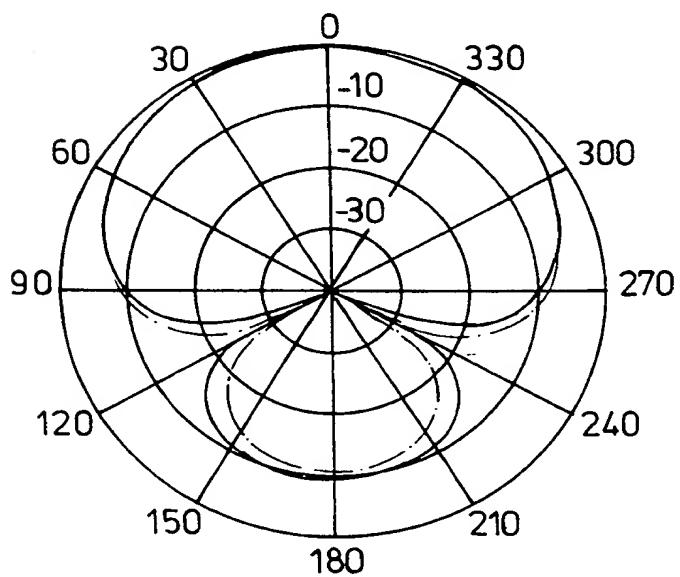
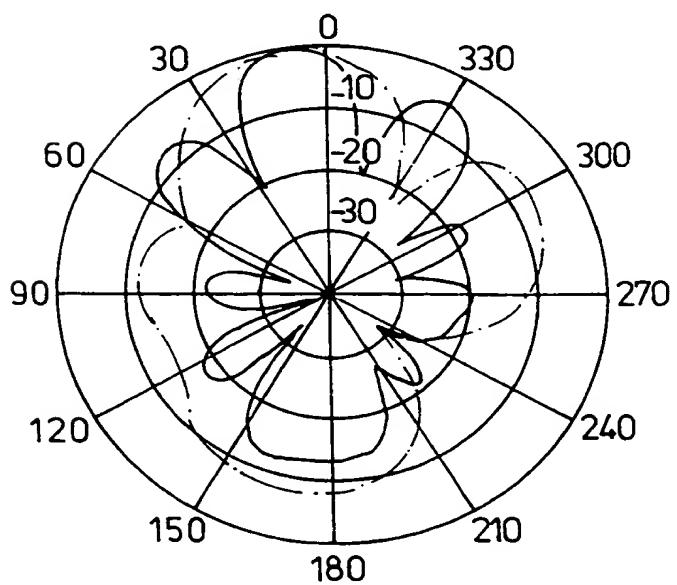


Fig - 6



3/3

fig - 7

